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1 CLAIMS

What is claimed is:

5 1. A method for computing a distance of a received word from a codeword, the codeword being a concatenation of L symbols selected from two disjoint symbol subsets X and Y, the codeword being included in one of a plurality of code-subsets, the received word being represented by L inputs, each of the L inputs uniquely corresponding to one of L dimensions, the method comprising the operations of:

10 (a) producing a set of one-dimensional errors from the L inputs, each of the one-dimensional errors representing a distance metric between one of the L inputs and a symbol in one of the two disjoint symbol-subsets; and

15 (b) combining the one-dimensional errors to produce a set of L-dimensional errors such that each of the L-dimensional errors is a distance of the received word from a nearest codeword in one of the code-subsets.

20 2. The method of claim 1 wherein each of the one-dimensional errors is represented by substantially fewer bits than each of the L inputs.

25 3. The method of claim 1 wherein operation (a) comprises the operation of slicing each of the L inputs with respect to each of the two disjoint symbol-subsets X and Y to produce a set of X-based errors, a set of Y-based errors and corresponding sets of X-based and Y-based decisions, the sets of X-based and Y-based errors forming the set of one-dimensional errors, the sets of X-based and Y-based decisions forming the set of one-dimensional decisions, each of the X-based and Y-based decisions being a  
 30 symbol in a corresponding symbol-subset closest in distance to one of the L inputs, each of the one-dimensional errors representing a distance metric between a corresponding one-dimensional decision and one of the L inputs.

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1           4.    The method of claim 3 wherein each of the one-dimensional errors is represented by 3 bits.

5           5.    The method of claim 3 wherein the operation of slicing is performed via a look-up table.

6.    The method of claim 5 wherein the look-up table is implemented using a read-only-memory storage device.

10          7.    The method of claim 5 wherein the look-up table is implemented using a random-logic device.

8.    The method of claim 1 wherein operation (a) comprises the operation of:

15           (1)   slicing each of the L inputs with respect to each of the two disjoint symbol-subsets X and Y to produce a set of X-based decisions and a set of Y-based decisions, the sets of X-based and Y-based decisions forming the set of one-dimensional decisions, each of the X-based and Y-based decisions being a  
20   symbol in a corresponding symbol-subset closest in distance to one of the L inputs;

          (2)   slicing each of the L inputs with respect to a symbol-set comprising all symbols of the two disjoint symbol-subsets to produce a set of hard decisions; and

25           (3)   combining each of the sets of X-based and Y-based decisions with the set of hard decisions to produce the set of one-dimensional errors, each of the one-dimensional errors representing a distance metric between the corresponding one-dimensional decision and one of the L inputs.

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9.    The method of claim 8 wherein operations (1), (2) and (3) are performed via a look-up table.

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35          10.   The method of claim 9 wherein the look-up table is implemented using a read-only-memory storage device.

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1           11. The method of claim 9 wherein the look-up table is  
implemented using a random-logic device.

5           12. The method of claim 8 wherein each of the one-  
dimensional errors is represented by one bit.

13. The method of claim 1 wherein operation (b) comprises  
the operations of:

10           combining the one-dimensional errors to produce two-  
dimensional errors;

            combining the two-dimensional errors to produce  
intermediate L-dimensional errors;

            arranging the intermediate L-dimensional errors into  
pairs of errors such that the pairs of errors correspond one-to-  
15 one to the code-subsets; and

            determining a minimum for each of the pairs of errors,  
the minima being the L-dimensional errors.

20           14. The method of claim 1 wherein L is equal to 4.

15. The method of claim 1 wherein the plurality of code-  
subsets comprises  $2^{L-1}$  code-subsets.

25           16. The method of claim 15 wherein the set of one-  
dimensional errors comprises 2L one-dimensional errors.

17. The method of claim 16 wherein the set of L-dimensional  
errors comprises  $2^{L-1}$  L-dimensional errors.

30           18. The method of claim 17 wherein operation (b) comprises  
the operations of:

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            combining the 2L one-dimensional errors to produce 2L  
~~two-dimensional errors;~~

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            combining the 2L two-dimensional errors to produce the  
35  $2^L$  intermediate L-dimensional errors;

- 1           arranging the  $2^L$  intermediate L-dimensional errors into  
           $2^{L-1}$  pairs of errors such that the  $2^{L-1}$  pairs of errors correspond  
          one-to-one to the  $2^{L-1}$  code-subsets; and  
          determining a minimum for each of the  $2^{L-1}$  pairs of  
5       errors, the minima being the  $2^{L-1}$  L-dimensional errors.

19. A system for computing a distance of a received word  
from a codeword, the codeword being a concatenation of L symbols  
selected from two disjoint symbol-subsets X and Y, the codeword  
10       being included in one of a plurality of code-subsets, the  
received word being represented by L inputs, each of the L inputs  
uniquely corresponding to one of L dimensions, the system  
comprising:

- (a) a set of slicers for producing a set of one-  
15       dimensional errors from the L inputs, each of the one-dimensional  
errors representing a distance metric between one of the L-inputs  
and a symbol in one of the two disjoint symbol-subsets; and  
          (b) a combining module for combining the one-  
dimensional errors to produce a set of L-dimensional errors such  
20       that each of the L-dimensional errors is a distance of the  
received word from a nearest codeword in one of the code-subsets.

20. The system of claim 19 wherein each of the one-  
dimensional errors is represented by substantially fewer bits  
25       than each of the L inputs.

21. The system of claim 19 wherein the slicers slice the  
L inputs with respect to each of the two disjoint symbol-subsets  
X and Y to produce a set of X-based errors, a set of Y-based  
30       errors and corresponding sets of X-based and Y-based decisions,  
the sets of X-based and Y-based errors forming the set of one-  
dimensional errors, the sets of X-based and Y-based decisions  
~~forming the set of one-dimensional decisions, each of the X-based~~  
and Y-based decisions being a symbol in a corresponding symbol-  
35       subset closest in distance to one of the L inputs, each of the

1 one-dimensional errors representing a distance metric between a  
corresponding one-dimensional decision and one of the L inputs.

22. The system of claim 21 wherein each of the one-  
5 dimensional errors is represented by 3 bits.

23. The system of claim 21 wherein the slicers are  
implemented using a look-up table.

10 24. The system of claim 23 wherein the look-up table is  
implemented using a read-only-memory storage device.

25. The system of claim 23 wherein the look-up table is  
implemented using a random-logic device.

15 26. The system of claim 19 wherein the set of slicers  
comprises:

(1) first slicers for slicing each of the L inputs  
with respect to each of the two disjoint symbol-subsets X and Y  
20 to produce a set of X-based decisions and a set of Y-based  
decisions, the sets of X-based and Y-based decisions forming the  
set of one-dimensional decisions, each of the X-based and Y-based  
decisions being a symbol in a corresponding symbol-subset closest  
in distance to one of the L inputs;

25 (2) second slicers for slicing each of the L inputs  
with respect to a symbol-set comprising all symbols of the two  
disjoint symbol-subsets to produce a set of hard decisions; and

(3) error-computing modules for combining each of the  
sets of X-based and Y-based decisions with the set of hard  
30 decisions to produce the set of one-dimensional errors, each of  
the one-dimensional errors representing a distance metric between  
the corresponding one-dimensional decision and one of the L  
inputs.

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1           27. The system of claim 26 wherein the first and second  
slicers and the error computing modules are implemented using a  
look-up table.

5           28. The system of claim 27 wherein the look-up table is  
implemented using a read-only-memory storage device.

          29. The system of claim 27 wherein the look-up table is  
implemented using a random-logic device.

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          30. The system of claim 26 wherein each of the one-  
dimensional errors is represented by one bit.

          31. The system of claim 19 wherein the combining module  
15 comprises:

          a first set of adders for combining the one-dimensional  
errors to produce two-dimensional errors;

          a second set of adders for combining the two-  
dimensional errors to produce intermediate L-dimensional errors,  
20 the intermediate L-dimensional errors being arranged into pairs  
of errors such that the pairs of errors correspond one-to-one to  
the code-subsets; and

          a minimum-select module for determining a minimum for  
each of the pairs of errors, the minima being the L-dimensional  
25 errors.

          32. The system of claim 19 wherein L is equal to 4.

          33. The system of claim 19 wherein the plurality of code-  
30 subsets comprises  $2^{L-1}$  code-subsets.

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          34. The system of claim 33 wherein the set of one-  
dimensional errors comprises 2L one-dimensional errors.

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1           35. The system of claim 34 wherein the set of L-dimensional errors comprises  $2^{L-1}$  L-dimensional errors.

5           36. The system of claim 35 wherein the combining module comprises:

          a first set of adders for combining the 2L one-dimensional errors to produce 2L two-dimensional errors;

          a second set of adders for combining the 2L two-dimensional errors to produce the  $2^L$  intermediate L-dimensional errors, the  $2^L$  intermediate L-dimensional errors being arranged  
10 into  $2^{L-1}$  pairs of errors such that the  $2^{L-1}$  pairs of errors correspond one-to-one to the  $2^{L-1}$  code-subsets; and

          a minimum-select module for determining a minimum for each of the  $2^{L-1}$  pairs of errors, the minima being the  $2^{L-1}$  L-dimensional errors.  
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          37. The system of claim 19 wherein the system is included in a communication transceiver configured to transmit and receive information signals encoded in accordance with a multi-level  
20 symbolic scheme.

          38. A method for computing a distance of a received word from a codeword, the codeword being a concatenation of L symbols selected from two disjoint symbol-subsets, the codeword being  
25 included in one of  $2^{L-1}$  code-subsets, the received word being represented by  $2^{L-1}$  input sets, each of the  $2^{L-1}$  input sets having L inputs, each of the L inputs uniquely corresponding to one of L dimensions, each of the  $2^{L-1}$  input sets corresponding to one of the  $2^{L-1}$  code-subsets, the method comprising the operations of:

30           (a) slicing each of the L inputs of each of the  $2^{L-1}$  input sets with respect to each of the two disjoint symbol-subsets to produce an error set of 2L one-dimensional errors for each of the  $2^{L-1}$  code-subsets; and

          (b) combining one-dimensional errors within each of  
35 the error sets to produce  $2^{L-2}$  L-dimensional errors for the



1 corresponding code-subset such that each of the  $2^{L-2}$  L-dimensional errors is a distance of the received word from one of codewords.

39. The method of claim 38 wherein L is equal to 4.

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40. The method of claim 38 wherein operation (b) comprises the operations of:

combining the 2L one-dimensional errors to produce 2L two-dimensional errors;

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combining the 2L two-dimensional errors to produce a set of  $2^L$  intermediate L-dimensional errors;

arranging the  $2^L$  intermediate L-dimensional errors into  $2^{L-1}$  pairs of errors such that the  $2^{L-1}$  pairs of errors correspond one-to-one to the  $2^{L-1}$  code-subsets; and

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determining a minimum for each of the  $2^{L-1}$  pairs, the minima being the  $2^{L-1}$  L-dimensional errors.

41. The method of claim 40 wherein operation (a) comprises the operation of producing a decision set of 2L one-dimensional decisions for each of the  $2^{L-1}$  code-subsets.

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42. The method of claim 40 wherein operation (b) comprises the operation of combining one-dimensional decisions within each of the decision sets to produce  $2^{L-2}$  L-dimensional decisions for the corresponding code-subset such that each of the  $2^{L-2}$  L-dimensional decisions is a codeword closest in distance to the received word, the codeword being in one of  $2^{L-2}$  code-subsets included in the  $2^{L-1}$  code-subsets.

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43. The method of claim 38 wherein the method is performed in a communication transceiver configured to transmit and receive information signals encoded in accordance with a multi-level symbolic scheme.

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